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It has been shown that equilibrium fluctuation analysis offers a fundamentally different approach to characterization of dynamic properties of various electrochemical systems ranging from fast redox couples, to liquid/liquid interface, bilayer membranes and even insulator/solution interface. These measurements can be extended to frequencies approximately one decade below those normally used in AC impedance analysis. The representation of power spectra on logarithmic scale of frequencies without distortion has been developed.

Chemical modulation of work function has been identified as an important factor which has to be considered in application of materials such as synthetic metals. Our preliminary study shows that a rigorous control of electropolymerization conditions can produce materials of widely different work function.

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Contract NOOO14-87-0060

STOCHASTIC PROCESSES IN CHEMFETS

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FINAL REPORT SUMMARY

The main goal of this contract was to develop the technique of equilibrium fluctuation analysis and to apply it to electrochemical problems. The distinguishing feature of equilibrium as opposed to non-equilibrium fluctuation analysis is that the origin of the signal is in thermal fluctuations. In equilibrium measurements the system is in the state of thermodynamic equilibrium while in non-equilibrium fluctuations the system under study is driven by e.g. externally imposed current. In the initial stages of the contract we have shown that using closely coupled field-effect transistors we could study and interpret dynamic characteristics of equilibrium electrochemical systems. In the last year of the project we have extended this work to study of equilibrium fluctuations at liquid/liquid interface and in phospholipid bilayer membranes. These studies were done with a discrete amplifiers as opposed to FETs used before.

The only non-equilibrium, but still zero current, fluctuation study done under this contract was the observation of electrochemical noise generated by silicon oxynitride under chemical etching conditions.

Approximately 15% of funds were used to investigate the physics and chemistry of a new type of transistor in which the metal gate is suspended above the gate insulator. This device is a general tool for investigation of chemical modulation of work function of synthetic metals and other conductors. It is also a generic structure for new class of solid state chemical sensors for gases.

Significant Results

We have shown that equilibrium fluctuation analysis offers a fundamentally different approach to characterization of dynamic properties of various electrochemical systems ranging from fast redox couples, to liquid/liquid interface, bilayer membranes and even insulator/solution interface. These measurements can be extended to frequencies approximately one decade below those normally used in AC impedance analysis.

The representation of power spectra on logarithmic scale of frequencies without distortion has been developed. Because this is a new approach to digital filtering we have applied for a patent protection.

Chemical modulation of work function of new electronic materials has been identified as an important factor which has to be considered in application of materials such as synthetic metals. Our preliminary study shows that a rigorous control of electropolymerization conditions can produce materials of widely different work function.

Seventeen papers have been published in refereed journals as the result of this contract. There have been more than fifty invited presentations and the principal investigator was awarded the Alexander von Humboldt Prize for chemistry in 1987 for work which was partially supported by this contract.

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